Final draft **ETSI EN 302 296** V2.2.1 (2021-03)

HARMONISED EUROPEAN STANDARD

**Digital Terrestrial TV Transmitters;
Harmonised Standard for access to radio spectrum**

ETSI

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Foreword

This final draft Harmonised European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the Vote phase of the ETSI standards EN Approval Procedure.

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.3] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.2].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	18 months after doa

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

The present document has been produced to update the existing ETSI EN 302 296 in line with the requirements of article 3.2 of Directive 2014/53/EU [i.2].

1 Scope

The present document specifies technical characteristics and methods of measurements for digital terrestrial television transmitters as defined in table 1.1 and in table 1.2. The power classification (table 1.1) and emission classification (table 1.2) are combined to define a transmitter category. For example, power classification H and emission classification 0 denote a high power transmitter (category H0) whose OOB emissions comply with a non-critical mask.

Table 1.1: Transmitter power classification

Power Class	Description	Notes
H	High power transmitter	Transmitter with an output power ≥ 25 W operating in the VHF band (174 MHz to 230 MHz) or UHF band (470 MHz to 694 MHz).
L	Low power transmitter	Transmitter with an output power < 25 W operating in the VHF band (174 MHz to 230 MHz) or UHF band (470 MHz to 694 MHz).

Table 1.2: Transmitter emission classification

Emission Classification	Conformance approach	Notes
0	Non-critical mask	For high power transmitters, the mask defines the level of the OOB emissions relative to the channel power (dBc). For low power transmitters the mask defines the absolute power limit of the OOB emissions (dBm). The former approach is mandated by RRC-06 (non-critical case) [i.4] for transmitters subject to coordination.
1	Critical mask	A similar but more stringent approach based on ITU RRC-06 (sensitive case) [i.4].
2	Non-critical ACLR	A set of ACLR limits defining permitted relative emission levels into adjacent channels.
3	Critical ACLR	A set of more stringent ACLR limits defining permitted relative emission levels into adjacent channels.

NOTE: The relationship between the present document and essential requirements of article 3.2 of Directive 2014/53/EU [i.2] is given in annex A.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

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The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2   Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1]   ETSI TR 101 290 (V1.2.1) (05-2001): "Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems".

[i.2]   Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.3]   Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.

[i.4]   ITU RRC-06: "Final Acts of the Regional Radiocommunication Conference for planning of the digital terrestrial broadcasting service in parts of Regions 1 and 3, in the frequency bands 174-230 MHz and 470-862 MHz", Geneva, 15 May - 16 June 2006.

[i.5]   ETSI EN 300 744 (V1.6.2) (10-2015): "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television".

[i.6]   ETSI EN 302 755 (V1.4.1) (07-2015): "Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)".

[i.7]   ETSI TR 100 028 (all parts) (V1.4.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[i.8]   ETSI TR 100 028-2 (V1.4.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2".

[i.9]   EN 55016-4-2:2011/A1:2014: "Specification for radio disturbance and immunity measuring apparatus and methods. Part 4-2: Uncertainties, statistics and limit modelling - Measurement instrumentation uncertainty", produced by CENELEC.

[i.10]   Recommendation ITU-R SM.329-12 (09/2012): "Unwanted emissions in the spurious domain".

3   Definition of terms, symbols and abbreviations

3.1   Terms

For the purposes of the present document, the terms given in Directive 2014/53/EU [i.2] and the following apply:

adjacent channel leakage ratio: ratio of the wanted mean power of the DVB-T/T2 signal to the unwanted mean power measured in the receiver bandwidth of a given adjacent victim service

antenna port: port of an apparatus intended to be connected to an antenna using coaxial cable or coaxial line; typically the output of the channel filter or combiner

carrier power: mean power supplied to the antenna port by a transmitter with COFDM

channel bandwidth: bandwidth supporting a single DVB-T or DVB-T2 signal

> NOTE: There are two possible channel bandwidths: 7 MHz or 8 MHz.

composite approach: measurement method whereby the power amplifier emissions are measured separately to the frequency response of subsequent frequency selective components and the overall emissions of the transmitter are calculated by combining the two sets of measurements

co-sited: DVB-T/T2 transmitters which are located at the same physical site so minimizing the effects of adjacent channel interference

critical mask: mask used for the sensitive case in ITU RRC-06 [i.4]

dBc: decibels relative to the *mean power P* of the emission

digital signal: discretely timed signal in which information is represented by a finite number of well-defined discrete values that its characteristic quantities may take in time

digital television: television in which all information is represented by a digital signal

environmental profile: range of environmental conditions under which equipment is expected to operate within the scope of the present document

harmonic: component of order greater than 1 of the Fourier series of a periodic quantity

high power transmitter: transmitter whose output power is greater than or equal to 25 W

> NOTE: This category of transmitter also includes medium power category of transmitters as defined in ITU-R.

intermodulation products: unwanted frequencies resulting from intermodulation between carriers or harmonics of emission, or between any oscillations generated to produce the carrier

low power transmitter: transmitter whose output power is less than 25 W

mean power: average power supplied to the antenna port by a transmitter during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation taken under normal operating conditions

moding: operation of a coaxial component in unwanted waveguide modes (e.g. Transverse Electric (TE) or Transverse Magnetic (TM)) resulting in anomalous behaviour from that associated with the intended Transverse Electromagnetic (TEM) mode

necessary bandwidth: for a given class of emission, the width of the frequency band which is sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions

non-critical mask: mask used for the non-critical case in ITU RRC-06 [i.4]

OOB emissions: unwanted emissions which fall at frequencies separated from the centre frequency of the wanted emission by less than or equal to 250 % of the channel bandwidth

output power: conducted power delivered by a transmitter under specified conditions of operation

receiver bandwidth: bandwidth used for victim service ACLR measurements, i.e. 7,6 MHz for 8 MHz DVB-T, 6,7 MHz for 7 MHz DVB-T, 7,8 MHz for 8 MHz DVB-T2, 6,8 MHz for 7 MHz DVB-T2 and 9 MHz for LTE

reference bandwidth: bandwidth in which the emission level is specified

spurious domain emissions: unwanted emissions at frequencies separated by more than 250 % of the channel bandwidth from the centre of the occupied spectrum

3.2   Symbols

For the purposes of the present document, the following symbols apply:

m	milli
µ	micro
n	nano
"	inch

3.3   Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 300 744 [i.5], ETSI EN 302 755 [i.6] and the following apply:

ACLR	Adjacent Channel Leakage Ratio
COFDM	Coded Orthogonal Frequency Division Multiplexing
CSV	Comma Separated Values
dB	Logarithmic ratio (tenths of a "Bel")
dBm	dB relative to one milliwatt
DIN	Deutsches Institut fur Normung
DTT	Digital Terrestrial Television
DVB	Digital Video Broadcasting
DVB-T	Digital Video Broadcasting - Terrestrial
DVB-T2	Digital Video Broadcasting - Second Generation Terrestrial
EFTA	European Free Trade Association
END	Equivalent Noise Degradation
EUT	Equipment Under Test
FFT	Fast Fourier Transform
GHz	GigaHertz
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union - Radiocommunication
kHz	kiloHertz
LTE	Long Term Evolution
MER	Modulation Error Ratio
MHz	MegaHertz
OOB	Out-Of-Band
PA	Power Amplifier
QAM	Quadrature Amplitude Modulation
RBW	Reference Bandwidth
RF	Radio Frequency
RMS	Root Mean Square
RRC	Regional Radiocommunication Conference
TV	TeleVision
UHF	Ultra High Frequency
VBW	Video Bandwidth
VHF	Very High Frequency
W	Watt

4   Technical requirements specifications

4.1   Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be in accordance with its intended use. The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the operational environmental profile defined by its intended use.

4.2   Conformance requirements

4.2.1   Introduction

The essential parameters and corresponding technical requirements aiming to meet the requirements of article 3.2 of Directive 2014/53/EU [i.2] are shown in table 4.1. To fulfil this essential parameter the compliance with all the corresponding technical requirements in table 4.1 shall be verified.

Table 4.1: Cross references

Essential parameter	Corresponding technical requirements
Conducted emissions at the antenna port	4.2.2 Spurious emissions
	4.2.3 Out-of-band emissions

Both spurious emission limits and OOB limits are defined in terms of output power at the antenna port.

The boundary between spurious domain emissions and out-of-band emissions is shown in figure 4.1.
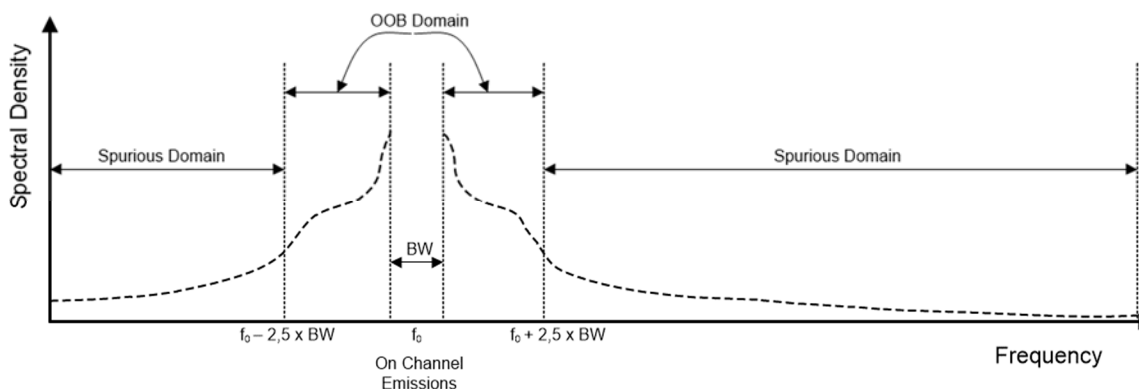
Figure 4.1: Definition of out-of-band and Spurious Domains

4.2.2   Spurious emissions

4.2.2.1   Definition

Spurious emissions are unwanted emissions at frequencies separated by more than 250 % of the channel bandwidth from the centre of the occupied spectrum. These include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products but exclude out-of-band emissions.

For the purposes of the present document spurious emissions are emissions at frequencies outside the frequency range $f_0 \pm 17,5$ MHz for 7 MHz channels, $f_0 \pm 20$ MHz for 8 MHz channels, where f_0 is the centre frequency of the channel, irrespective of the number of carriers employed.

4.2.2.2   Limits

Spurious emissions shall not exceed the values set out in table 4.2 additionally shown in figure 4.2, for the frequency range 9 kHz to 3 GHz.

Table 4.2: Spurious emission limits for DVB-T/T2 transmitters

Frequency range of the spurious emission	Limits of the spurious emission			Reference bandwidth
9 kHz to 470 MHz	≤ -36 dBm (250 nW) ≥ 105 dBc	for for	P ≤ 69 dBm 69 dBm < P	100 kHz
> 470 MHz to 694 MHz	≤ -36 dBm ≥ 75 dBc ≤ -25 dBm (3 µW)	for for for	P ≤ 39 dBm 39 dBm < P ≤ 50 dBm 50 dBm < P	100 kHz
> 694 MHz	≤ -36 dBm (250 nW) ≥ 105 dBc	for for	P ≤ 69 dBm 69 dBm < P	100 kHz
NOTE: P = mean power of the transmitter measured at the antenna port.				
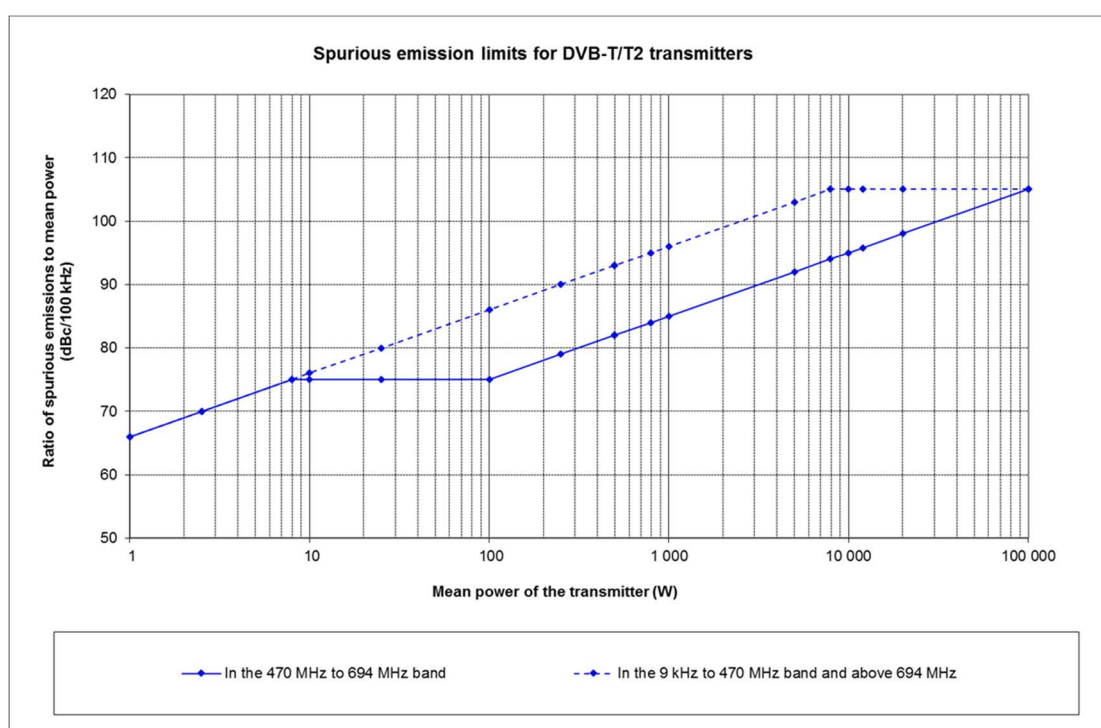
**Figure 4.2: Spurious emission limits measured at the antenna port
(100 kHz reference bandwidth)**

4.2.2.3   Conformance test

Conformance tests described in clause 5.4.2 shall be carried out.

4.2.3   Out-of-band emissions

4.2.3.1   Definition

Out-of-band emissions are unwanted emissions which fall at frequencies separated from the centre frequency of the wanted emission by less than or equal to 250 % of the channel bandwidth. For the purposes of the present document out-of-band emissions are emissions at frequencies outside the necessary bandwidth and within the frequency ranges $f_0 \pm 17,5$ MHz for 7 MHz channels, $f_0 \pm 20$ MHz for 8 MHz channels where f_0 is the centre frequency of the channel, irrespective of the number of carriers employed.

For mask-based approaches, the out-of-band emissions limits are given as mean power level measured at the antenna port in a 3 kHz bandwidth.

4.2.3.2   Classification of transmitters

Transmitters will be classified according to power and emissions according to table 1.1 and table 1.2.

With regard to the declaration of conformity, the manufacturer shall declare which classification the equipment complies with. For example, a transmitter conforming to classification H0 is a high power transmitter conforming to the non-critical mask.

4.2.3.3   Limits

Out-of-band emissions shall not exceed the values set out in table 4.3 to table 4.8, subject to the specific transmitter category (see table 1.1 and table 1.2).

Table 4.3 sets out the limits for transmitter classification L0. Table 4.4 sets out the limits for transmitter classification L1. Table 4.5 sets out the limits for transmitter classifications L2 and L3.

Table 4.6 sets out the limits for transmitter classification H0 additionally shown in figure 4.3 and figure 4.4 for 7 MHz channels and 8 MHz channels respectively. Table 4.7 sets out the limits for transmitter classification H1 additionally shown in figure 4.5 and figure 4.6 for 7 MHz channels and 8 MHz channels respectively. Table 4.8 sets out the limits for transmitter classification H3.

Table 4.3: OOB emission limits for classification L0

Transmitter Classification	Frequency offset for 7 MHz systems (MHz)	Frequency offset for 8 MHz systems (MHz)	Absolute power level (dBm/3 kHz)
L0	±3,41	±3,9	≤ 10
	±3,7	±4,2	≤ -30
(Low power, non-critical mask)	±5,25	±6	≤ -42
	±10,5	±12	≤ -67
	±17,5	±20	≤ -67

Table 4.4: OOB emission limits for classification L1

Transmitter Classification	Frequency offset for 7 MHz systems (MHz)	Frequency offset for 8 MHz systems (MHz)	Absolute power level (dBm/3 kHz)
L1	±3,41	±3,9	≤ 10
	±3,7	±4,2	≤ -40
(Low power, critical mask)	±5,25	±6	≤ -52
	±10,5	±12	≤ -77
	±17,5	±20	≤ -77

Table 4.5: OOB limits for transmitter classification L2 and L3

Transmitter Classification	First adjacent channel ACLR (dB)	Second adjacent channel ACLR (dB)
L2	≥ 42	≥ 64
L3	≥ 55	≥ 77
NOTE 1: The first and second adjacent channel frequency offsets are defined as 8 MHz and 16 MHz respectively for UHF transmitters and 7 MHz and 14 MHz respectively for VHF transmitters. NOTE 2: The integration bandwidth for the victim channel is defined as 7 MHz for VHF transmitters and 8 MHz for UHF transmitters.		

Table 4.6: OOB emission limits for classification H0

Transmitter Classification	Frequency offset for 7 MHz systems (MHz)	Frequency offset for 8 MHz systems (MHz)	Relative power level (dBc/3 kHz)
H0 (High power, non-critical mask)	±3,41	±3,9	≤ -34
	±3,7	±4,2	≤ -74
	±5,25	±6	≤ -86
	±10,5	±12	≤ -111
	±17,5	±20	≤ -111
NOTE: The limits for UHF transmitters using 8 MHz channels are plotted in figure 4.4. The limits for VHF transmitters using 7 MHz channels are plotted in figure 4.3.			

Figure 4.3: Out-of-band limits for transmitter classification H0 using 7 MHz channels

Figure 4.4: Out-of-band limits for transmitter classification H0 using 8 MHz channels

Table 4.7: OOB emission limits for classification H1

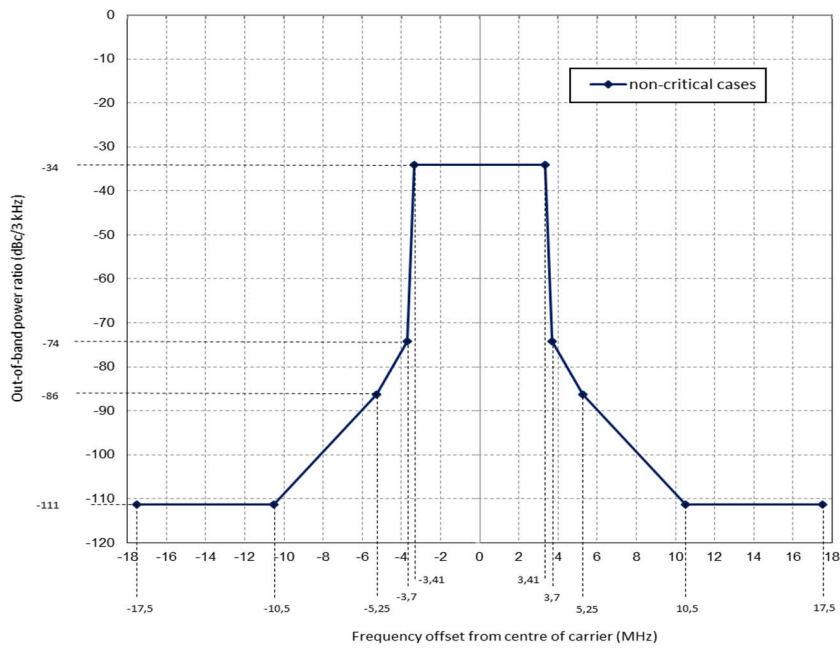| Transmitter Classification	7 MHz Channel, frequency difference from the centre frequency (MHz)	8 MHz Channel, frequency difference from the centre frequency (MHz)	Relative level (dBc/3 kHz)
H1 (High power, critical mask)	±3,41	±3,9	≤ -34
	±3,7	±4,2	≤ -84
	±5,25	±6	≤ -96
	±10,5	±12	≤ -121
	±17,5	±20	≤ -121
NOTE: The limits for UHF transmitters using 8 MHz channels are plotted in figure 4.6 and the limits for VHF transmitters using 7 MHz channels are plotted in figure 4.5.			

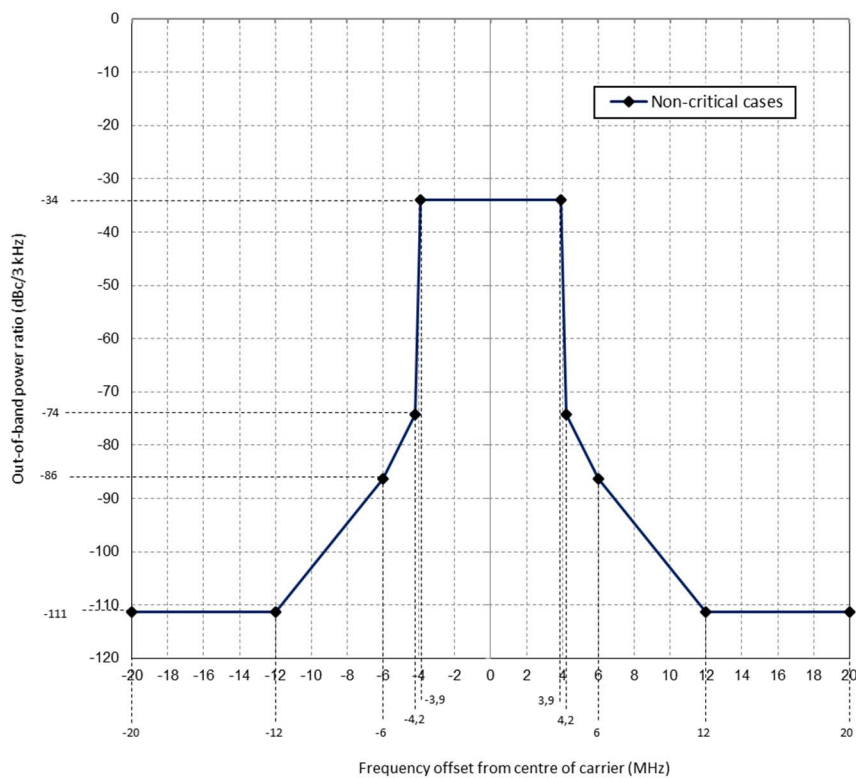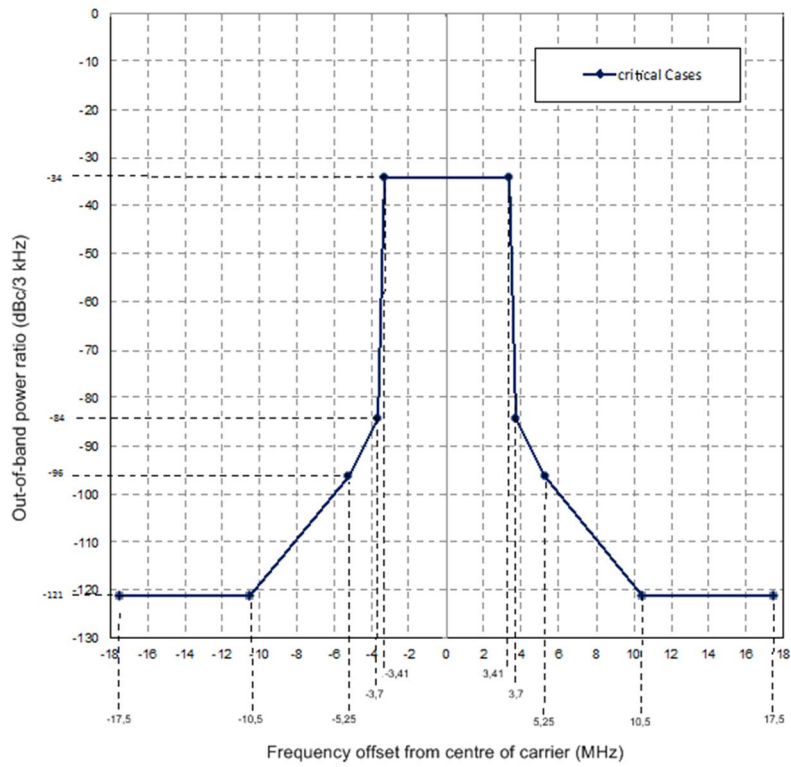**Figure 4.5: Out-of-band limits for transmitter classification H1 using 7 MHz channels**
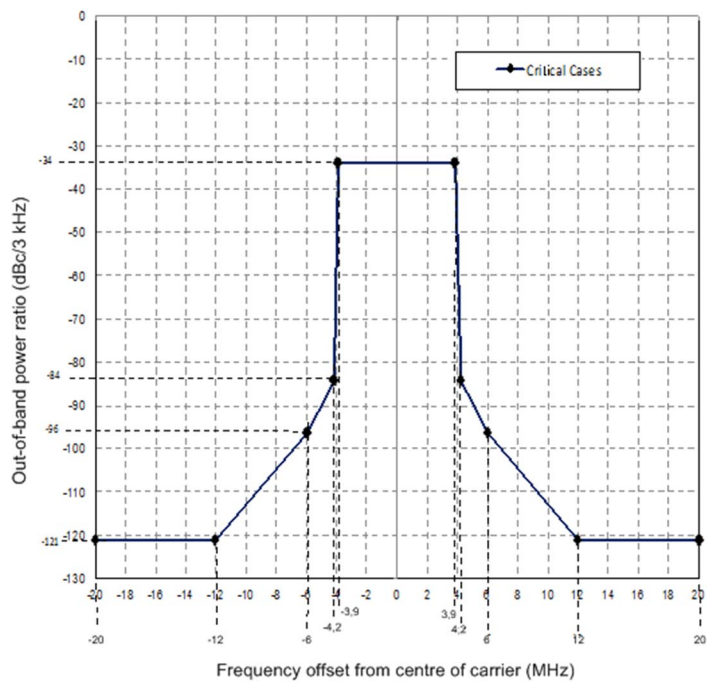

Figure 4.6: Out-of-band limits for transmitter classification H1 using 8 MHz channels

Table 4.8: OOB emission limits for classification H3

Transmitter Classification	UHF DVB-T/T2 ACLR limits (see note 1)		VHF DVB-T/T2 ACLR limits (see note 2)		LTE-800 ACLR limits (see note 3)		LTE-700 ACLR limits (see note 3)	
	Offset (MHz)	ACLR (dB)	Offset (MHz)	ACLR (dB)	Offset (MHz)	ACLR (dB)	Offset (MHz)	ACLR (dB)
H3 (critical ACLR)	±8	≥ 61	±7	≥ 61	+10	≥ 68	+18	≥ 86
	±16	≥ 87	±14	≥ 87	+20	≥ 86	N/A	N/A
NOTE 1: The ACLR limits are derived by integration of the critical mask defined in table 4.6 over the victim DVB-T/T2 bandwidth of 8 MHz.								
NOTE 2: For VHF DVB-T2 systems (7 MHz channels) the victim DVB-T/T2 service integration bandwidth is 7 MHz.								
NOTE 3: These values apply only for UHF transmitters. The victim service integration bandwidth is 10 MHz.								

4.2.3.4 Conformance test

Conformance tests described in clause 5.4.3 shall be carried out.

5 Testing for compliance with technical requirements

5.1 Environmental conditions for testing

Tests defined in the present document shall be carried out at representative points within the boundary limits of the operational environmental profile defined by its intended use.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the operational environmental profile defined by its intended use) to give confidence of compliance for the affected technical requirements.

5.2 Void

5.3 Test conditions

5.3.1 Test frequency range

Limits on unwanted emissions for radio equipment are considered to be applicable to the range 9 kHz to 3 GHz as per Recommendation ITU-R SM.329-12 [i.10], clause 2.

Before starting the testing procedure measurement uncertainty of the equipment in use, including cables and couplers shall be established and stated in the test report. Where measurement uncertainty within the limits contained in table F.1 cannot be achieved, the test report shall state the limiting circumstances.

The following reference bandwidths are to be used:

For spurious emissions:

- 100 kHz.

For out-of-band emissions:

- 3 kHz.

Table 5.1: Void

5.3.2   Test modulation signal

The following modulation parameters shall be used for the test.

Table 5.2: Test Signal Configuration

DVB-T		
Channel bandwidth	7 MHz	8 MHz
Receiver bandwidth	6,7 MHz	7,6 MHz
Modulation scheme	64-QAM	64-QAM
FFT size	8k	8k
DVB-T2		
Channel bandwidth	7 MHz	8 MHz
Receiver bandwidth	6,8 MHz	7,8 MHz
Modulation scheme	256-QAM	256-QAM
FFT size	32k	32k
Carrier mode	Extended	Extended

5.4   Essential radio test suites

5.4.1   Introduction

Broadcast DTT transmitters vary in power from a few W for a rebroadcast repeater to many kW for a main station. As a result, the specific equipment used to perform the testing may vary. At low powers, the use of attenuators to connect the output of the equipment to the test harness may be the best solution, but at higher powers this is impractical and the use of couplers will be more appropriate. The testing specified permits both approaches to be used and will produce the same results for demonstrating compliance to the limits stated in clause 4.

A broadcast DTT transmitter is considered to consist of a power amplifier and an output filter. Since the output filter is typically implemented as part of a combining system, a substitute physical or virtual output filter is required for the testing, because it is impractical to require all the other DTT transmitters to be present. The substitute output filter shall have the same characteristics as presented by the actual output filter system implemented, and may be realised in two ways:

- add a physical output filter after the power amplifier and make the antenna port measurements at the output of the physical output filter;

- add a virtual output filter after the power amplifier and make the antenna port measurements at the output of the power amplifier, using the composite approach to determine the results.

5.4.2   Spurious emissions

5.4.2.1   Measurement approaches

There are two practical approaches for the measurement of spurious emissions:

- Direct measurement using a high power attenuator between the antenna port and the spectrum analyser. This approach is more suited to low power transmitters.

- Measurements using a coupling device between the antenna port and the spectrum analyser. This approach is more suited to high power transmitters.

5.4.2.2   Initial conditions

Test environment:

- representative points within the boundary limits of the declared operational environmental profile for the transmitter system.

The test shall be carried out at the following frequencies:

1)   the lowest operating frequency of the EUT;

2)   the highest operating frequency of the EUT;

3)   a frequency corresponding to the arithmetic mean between 1) and 2) above, rounded to the nearest broadcast channel.

The full rated output power of the transmitter shall be maintained during this test with the modulation defined in clause 5.3.2.
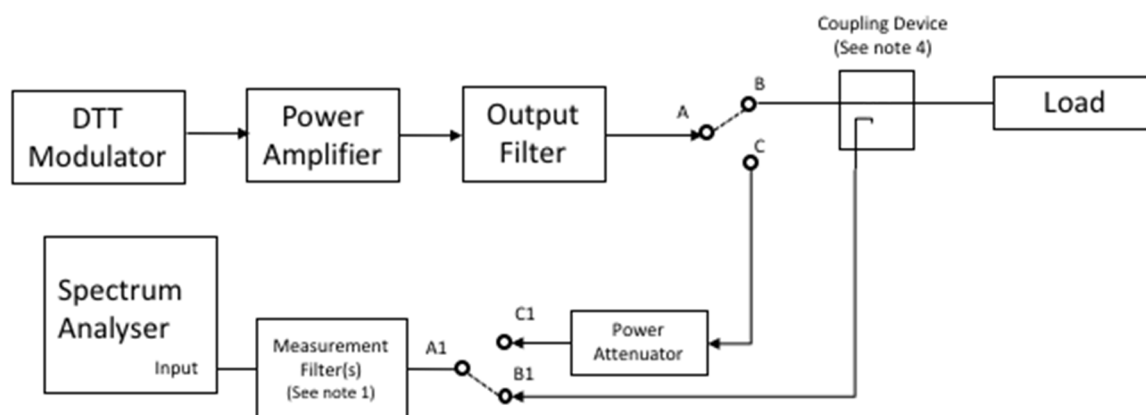
5.4.2.3   Test procedure

1)   Operate the EUT at each of the test frequencies as defined in clause 5.4.2.2.

2)   Measure the results on the spectrum analyser as described in clause 5.4.2.5, figure 5.1, note 1, note 2, note 3 and note 4.

5.4.2.4   Test requirements

The results obtained shall be compared to the limits in clause 4.2.2 in order to demonstrate compliance.

5.4.2.5   Test arrangement

NOTE 1:   The measurement filter should suppress the wanted output signal so that no intermodulation products are generated by the spectrum analyser. The insertion loss throughout the measuring range should be known.
NOTE 2:   For high power transmitters the preferred set up would require A to be connected to B and A1 to be connected to B1.
NOTE 3:   For low power transmitters the preferred set up would require A to be connected to C and A1 to be connected to C1.
NOTE 4:   The characteristics of the coupler will be frequency dependent and the coupling factor typically increases 6 dB/octave. Moding in high power coaxial feeders may prevent reliable measurements at high frequencies (see annex C). At low frequencies, the low coupling ratio may cause dynamic range concerns (see annex C).

Figure 5.1: Test arrangement for spurious emissions

5.4.3   Out-of-band emissions

5.4.3.1   Initial conditions

Test environment:

- Representative points within the boundary limits of the declared operational environmental profile for the transmitter system.

The manufacturer shall test at the following frequencies:

1)   the lowest operating frequency of the EUT;

2)   the highest operating frequency of the EUT;

3)   a frequency corresponding to the arithmetic mean between 1) and 2) above, rounded to the nearest broadcast channel.

The full rated output power of the transmitter shall be maintained during this test with the modulation defined in clause 5.3.2.
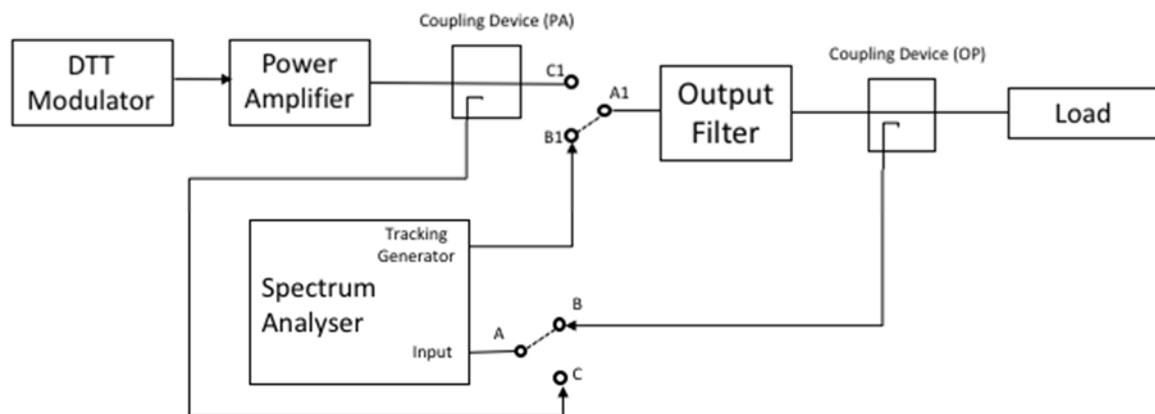
5.4.3.2   Test procedure

1)   Operate the EUT at each of the test frequencies as defined in clause 5.4.3.1.

2)   Measure the results on the spectrum analyser as described in clause 5.4.3.4, figure 5.2, notes 1 to 5.

5.4.3.3   Test requirements

The results obtained shall be compared to the limits in clause 4.2.3.3 in order to demonstrate compliance.

5.4.3.4   Test arrangement

NOTE 1: To overcome dynamic range limitations of typical spectrum analysers a composite measurement approach is utilized whereby the response of the output filter is characterized separately.
NOTE 2: With appropriate safety procedures in place, disconnect the power amplifier from the output filter. Care is required as this is an intrusive test.
NOTE 3: The frequency response of the output filter shall be measured and recorded (Connections A-B, A1-B1).
NOTE 4: The spectrum of the DVB-T/T2 signal at the output of the power amplifier shall be measured and recorded (Connections A-C, A1-C1).
NOTE 5: The resulting out-of-band spectrum of the transmitter shall be calculated by applying the recorded frequency response of the output filter (measured at note 3) to the recorded spectrum of the DVB-T/T2 signal (measured at note 4).

Figure 5.2: Testing arrangement for out-of-band emissions

Annex A (informative):
Relationship between the present document and the essential requirements of Directive 2014/53/EU

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.3] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.2].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

**Table A.1: Relationship between the present document and
the essential requirements of Directive 2014/53/EU**

Harmonised Standard ETSI EN 302 296					
Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive	Clause(s) of the present document	U/C	Condition
1	Spurious emissions	3.2	4.2.2.2	U	
2	Out-of-band emissions	3.2	4.2.3.3	U	

Key to columns:

Requirement:

> **No**   A unique identifier for one row of the table which may be used to identify a requirement.

> **Description**   A textual reference to the requirement.

> **Essential requirements of Directive**

>> Identification of article(s) defining the requirement in the Directive.

> **Clause(s) of the present document**

>> Identification of clause(s) defining the requirement in the present document unless another document is referenced explicitly.

Requirement Conditionality:

> **U/C**   Indicates whether the requirement is unconditionally applicable (U) or is conditional upon the manufacturer's claimed functionality of the equipment (C).

> **Condition**   Explains the conditions when the requirement is or is not applicable for a requirement which is classified "conditional".

Presumption of conformity stays valid only as long as a reference to the present document is maintained in the list published in the Official Journal of the European Union. Users of the present document should consult frequently the latest list published in the Official Journal of the European Union.

Other Union legislation may be applicable to the product(s) falling within the scope of the present document.

Annex B (informative):
Void

Annex C (informative):
Practical measurement of spurious domain emissions for broadcast transmitters

C.0   Introduction

The accurate measurement of spurious domain emissions is typically limited by the dynamic range of the spectrum analyser. It is usually necessary to use additional band-reject, low pass or high pass filters to remove the fundamental signal in order to reveal the unwanted spurious domain emissions.

C.1   Directional coupler issues

Measurements on live equipment connected to broadcast antennas are further complicated by practical issues relating to the couplers used to probe the transmitter output signal. These typically exhibit a frequency dependent response which should be accounted for in the measurement. Directional couplers usually exhibit a response whereby the coupling factor increases 6 dB octave as shown in figure C.1 for a device for use with a 1 5/8" feeder.
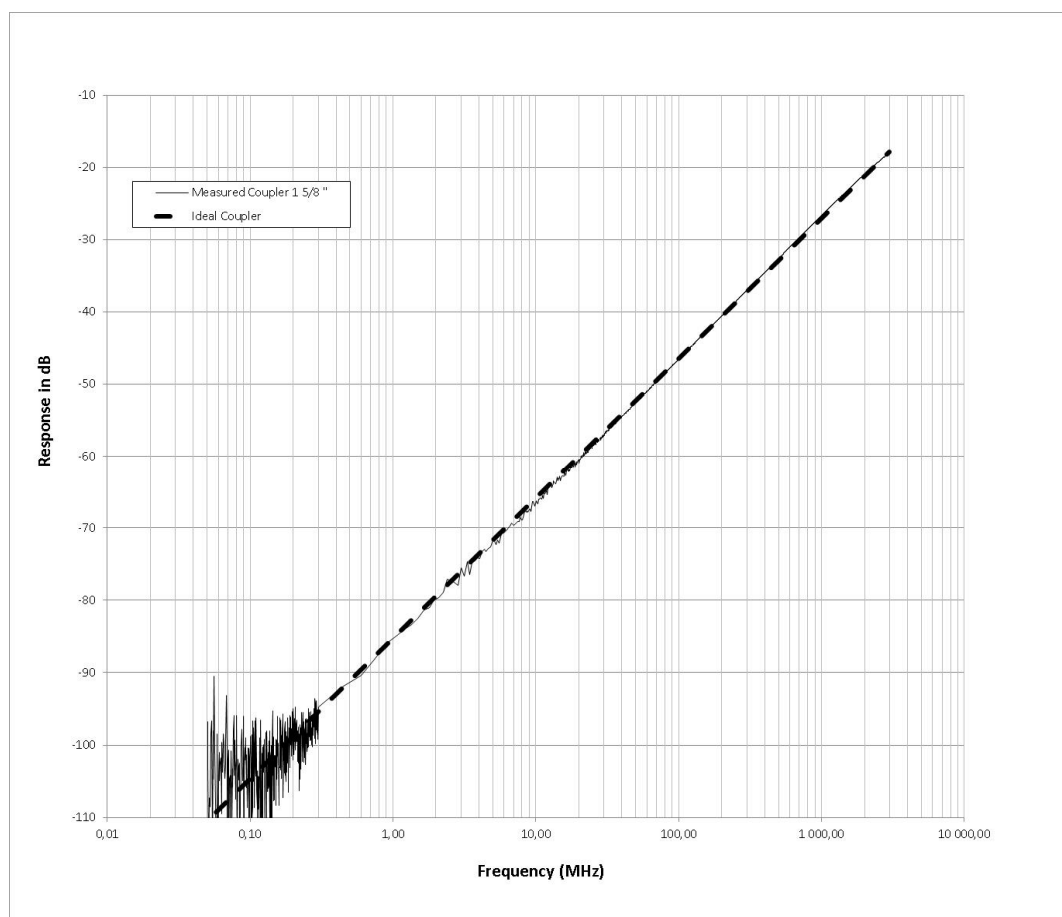

Figure C.1: Typical Measured Directional Coupler Frequency Response (1 5/8" feeder)

At low frequencies, the decreasing coupling factor results in a low signal level and the spurious domain measurement will typically be limited by the noise floor of the spectrum analyser (see figure C.1). So called 'hot couplers' with higher coupling ratio can be used to extend the measurement range, but great care is needed to avoid damage to test equipment.

For high power transmitters, where large diameter coaxial connections are used to handle the signals, the propagation of higher order waveguide modes within the couplers and feeders results in anomalous responses and impedance mismatches which cannot be accounted for by calibration. Such behaviour sets an upper bound on the frequency of measurement. Typical moding behaviour for a 4 1/2" coupler is shown in figure C.2 and results in unpredictable behaviour above 1,2 GHz. Table C.1 shows maximum operating frequencies for common line sizes.
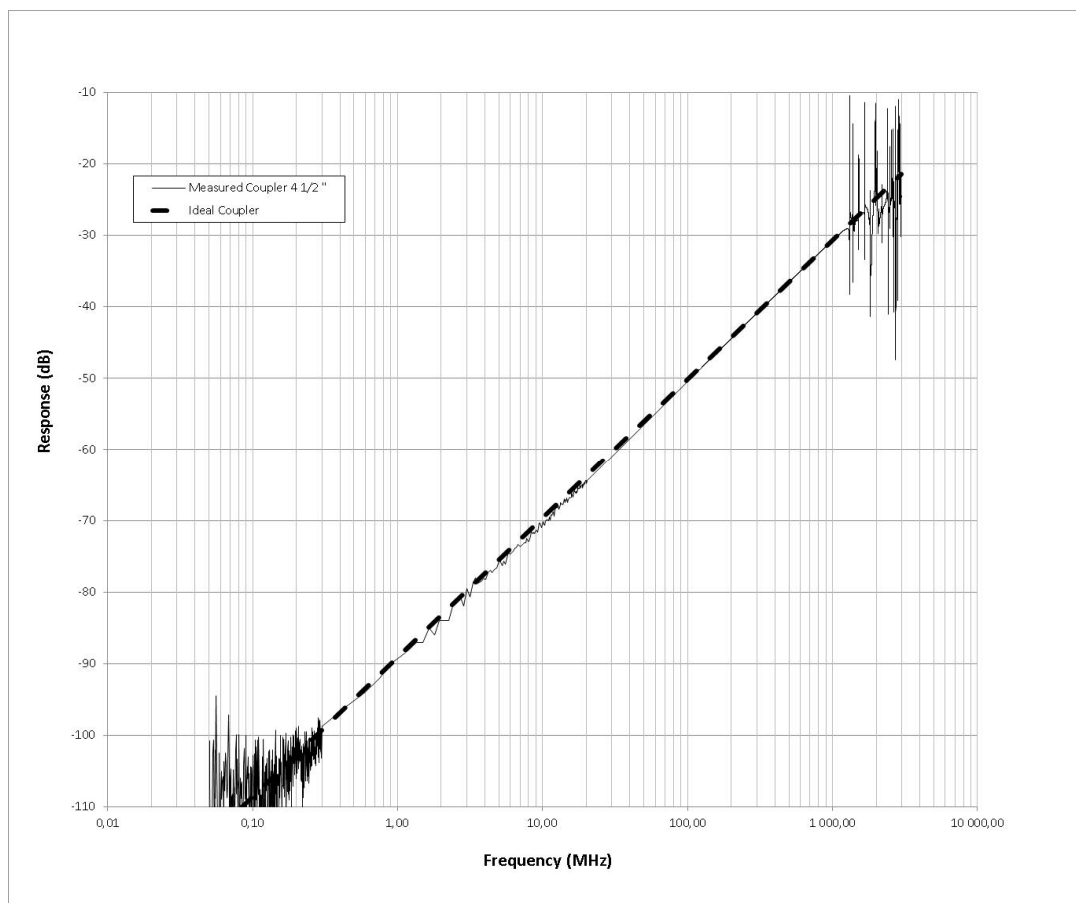

Figure C.2: Directional Coupler Frequency Response due to Moding (4 1/2" feeder)

Table C.1: Cut-off Frequencies for Common Line Sizes

Line Size	Recommended Maximum Frequency (MHz)
N	18 000
7 16 (DIN)	8 300
1 5/8 "	3 200
3 1/8 "	1 600
4 1/2 "	1 200
6 1/8 "	830

C.2   Spectrum analyser settings

The accuracy of the spurious measurement is influenced by the configuration of the spectrum analyser. The parameters in table C.2 are suggested as a starting point appropriate for typical spectrum analysers.

Table C.2: Suggested spectrum analyser settings for spurious measurements

Parameter	Setting
Resolution Bandwidth (RBW)	100 kHz
Detector	RMS
Sweep time (s)	Span (MHz)/25
Number of Measurement Points	35 × Span (MHz)
Video Bandwidth (VBW)	100 kHz
Trace averaging	Off
Trace mode	Clear-Write

C.3   Composite measurement of spurious emissions

The RF transmission response seen in figure C.1 and figure C.2 show very low coupling factors at low frequencies and higher coupling factors at frequencies above the operating channel.

In order to overcome this effect a composite measurement approach can be adopted as follows:

- The levels of the spurious emissions at the output of the output filter may be calculated by weighting the measured result with the frequency response of the coupler. This calculation can be carried out off-line.

Annex D (informative):
Practical Measurement of out-of-band Domain Emissions

D.1   Composite measurement of out-of-band emissions

It is recognized that the absolute signal range associated with the OOB mask (or ACLR limit) will exceed the dynamic range measurement capability of most modern RF spectrum analysers. Since typical transmitter systems comprise a Power Amplifier (PA) and an output channel filter, the dynamic range restriction can be overcome by a composite measurement technique whereby:

1) The response of the output filter is first measured using a spectrum analyser equipped with a tracking generator. The log-magnitude response, *H(f)*, is typically stored either in the instrument or as a text file (typically Comma Separated Variable (CSV) or as S-parameters). Some instruments allow the filter response to be stored internally for later use.

2) The out of block emissions are measured at a coupler connected between the output of the power amplifier and the input to the output filter. The log-magnitude response, *P(f)*, can typically be stored as a CSV text file.

3) The spectrum of the out-of-band emissions at the antenna port is calculated by weighting the PA measurement 2) by the response of the output filter 1). This calculation (*P'(f) = P(f) + H(f)*) can be either carried out off-line (e.g. in a computer spread sheet), or automatically using a suitably equipped spectrum analyser. The latter is typically implemented using 'trace math' functions which allow the log-magnitude response measured in 1) to be added to the PA spectrum response measured in 2).

4) The ACLR is defined as the ratio of the wanted mean power of the DVB-T/T2 signal to the unwanted mean power measured in the receiver bandwidth of a given adjacent victim service. These two quantities can be calculated from the spectrum of the out-of-band emissions *P'(f)* 3). This can be achieved directly on some analysers, or off-line by a numerical linear power sum of the composite trace data.

5) The ACLR can be estimated from the spectrum analyser trace data, P_i, using the following summation:

$$ ACLR = 10 \times log_{10} \left\{ \frac{\kappa_w \times \sum_{i=w_l}^{w_u} 10^{\frac{P_i'(f_i)}{10}}}{\kappa_v \times \sum_{i=v_l}^{v_u} 10^{\frac{P_i'(f_i)}{10}}} \right\} \approx 10 \times log_{10} \left\{ \frac{\sum_{i=w_l}^{w_u} 10^{\frac{P_i'(f_i)}{10}}}{\sum_{i=v_l}^{v_u} 10^{\frac{P_i'(f_i)}{10}}} \right\} $$

Where:

$P_i(f_i)$ is the measured power of the ith measurement point in the spectrum analyser trace data at frequency f_i expressed in dBm. This will be measured in a bandwidth determined by the resolution bandwidth setting of the analyser;

$H(f_i)$ is the measured response of the output filter at frequency f_i expressed in dB;

$P_i'(f_i)$ is the the calculated power of the ith measurement point at frequency f_i expressed in dBm given by $P_i'(f_i) = P_i(f_i) + H(f_i)$;

κ_w, κ_v are scaling factors relating the numerical summation in the above equation to the effective power in the wanted and adjacent channels. They are dependent on the spectrum analyser filter characteristics and the number of measurement points. Given a sufficiently high number of measurement points, $\kappa_w = \kappa_v$;

w_l is the index of the measurement point corresponding to the lower frequency bound of the wanted signal;

w_u is the index of the measurement point corresponding to the upper frequency bound of the wanted signal;

v_l is the index of the measurement point corresponding to the lower frequency bound of the adjacent victim signal;

v_u is the index of the measurement point corresponding to the upper frequency bound of the adjacent victim signal.

For a set of N measurement points across a frequency sweep of f_{span}, the required measurement point indices are given by:

$$w_l = ceiling\left(\frac{\left\{\frac{f_{span}}{2}-\frac{B_W}{2}\right\}}{\Delta f}\right)$$

$$w_u = floor\left(\frac{\left\{\frac{f_{span}}{2}+\frac{B_W}{2}\right\}}{\Delta f}\right)$$

$$v_l = ceiling\left(\frac{\left\{\frac{f_{span}}{2}+f_{offset,v}+\frac{B_v}{2}\right\}}{\Delta f}\right)$$

$$v_u = floor\left(\frac{\left\{\frac{f_{span}}{2}+f_{offset,v}-\frac{B_v}{2}\right\}}{\Delta f}\right)$$

Where:

f_{span} is the frequency span of the spectrum analyser sweep;

$f_{offset,v}$ is the frequency offset of the centre frequency of the victim channel from the wanted DTT channel;

B_v is the bandwidth of the victim service;

B_w is the bandwidth of the wanted service;

Δf is the frequency interval between spectrum analyser measurement points, ($\frac{f_{span}}{N}$);

N is the number of measurement points (typically 501 for ACLR calculations).

D.2   System considerations

The precise response of the output filter is typically affected by the impedance of the antenna and combiner which will have a finite return loss.
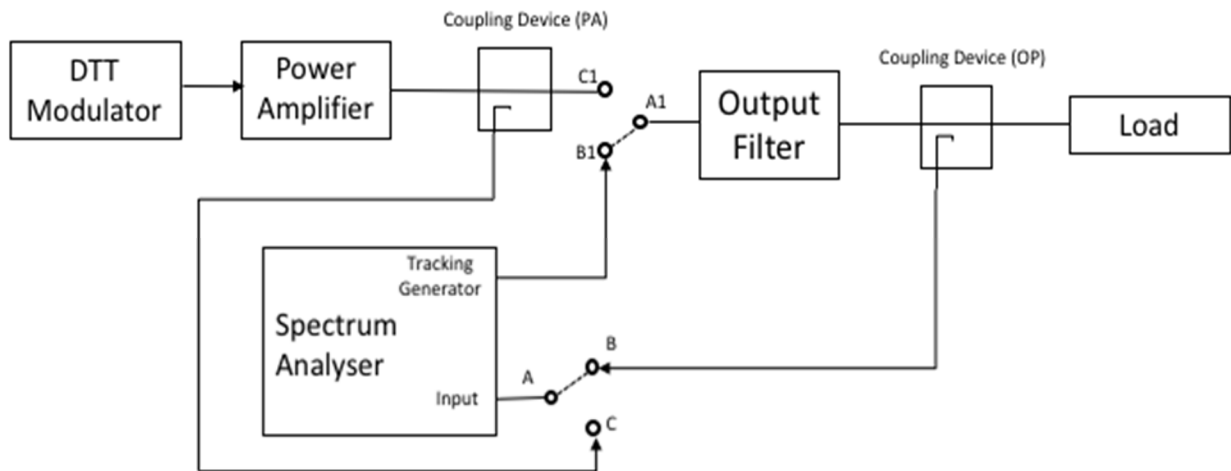

Figure D.1: Practical arrangement for measuring the response of the Output Filter

D.3   Spectrum analyser settings for OOB measurements

The accuracy of the OOB emissions measurement is influenced by the configuration of the spectrum analyser. The following parameters are suggested as a starting point appropriate for typical spectrum analysers.

Table D.1: Suggested spectrum analyser settings for OOB emissions measurements

Parameter	Setting
Resolution Bandwidth (RBW)	3 kHz
Detector	RMS
Span	40 MHz
Sweep time	30 s
Number of Measurement Points (see note 1 and note 2)	501
Video Bandwidth (VBW)	3 kHz
Trace averaging	Off
Trace mode	Clear-Write
NOTE 1: OOB mask tests: It may be desirable to increase the number of points to 801 for mask compliance testing. NOTE 2: Narrow band victim services will require an increased number of measurement points, typically N > 10 across the bandwidth of the victim service for ~1 dB precision. Increasing the number of analyser points will improve the precision.	

D.4   OOB domain emissions - typical spectrum analyser traces

Plot 1 to plot 3 below show example spectrum analyser measurement traces from the methodology described in clause D.1, clause D.2 and clause D.3 above.

Plot 1 shows the RF filter transmission loss.

Plot 2 shows the Transmitter performance before RF Filter/combiner.

Plot 3 shows the Composite trace derived from the addition of plot 1 and plot 2. Note the Non critical mask is also displayed on this plot.
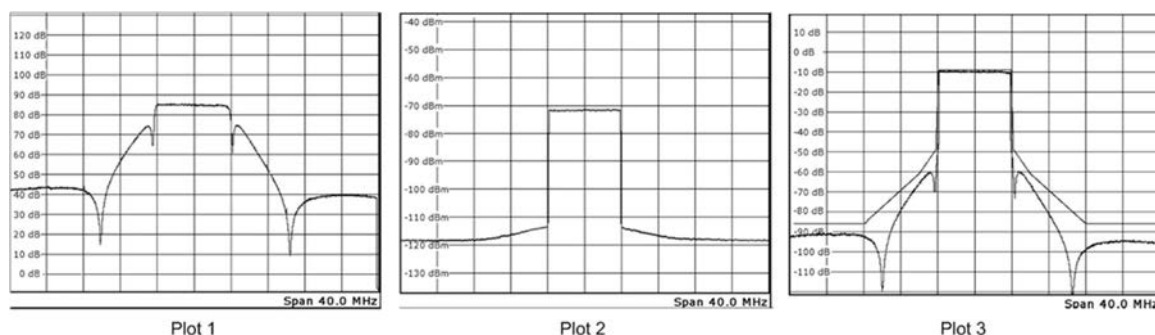

Figure D.2: Typical RF Analyser Traces

D.5 ACLR measurement

Figure D.3 shows an example DVB-T2 ACLR measurement of first and second adjacent 7,8 MHz victim channels in 8 MHz spacing. In this case the ACLR values are automatically calculated in the instrument from the OOB composite plot.
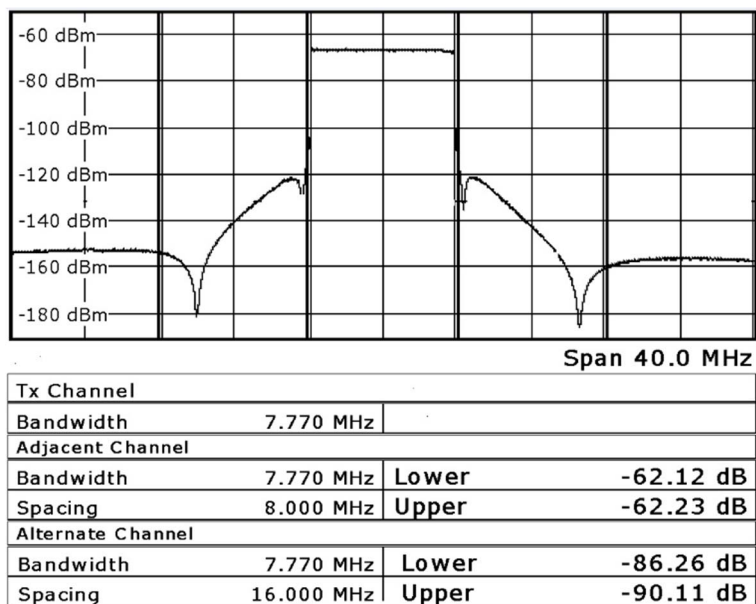

Figure D.3: ACLR Composite Trace Measurement

Annex E (informative):
Impact of ACLR of low power broadcast transmitters on adjacent DVB-T/T2 services for co-sited networks

E.0   Introduction

ACLR limits included in clause 4.2.3.3, table 4.5, were derived from a series of bench tests, designed to record the impact for a range of DVB-T/T2 transmitter ACLR values on equal power adjacent DVB-T/T2 transmitters (e.g. for a co-sited network). In this case the ACLR (in dB) is defined as the ratio between the integrated power in adjacent DVB-T/T2 channel to the mean power in the wanted channel. For co-sited, 8 MHz DVB-T (DVB-T2) networks, the adjacent victim channel offset is 8 MHz in-line with the UHF channel raster, with a 7,6 MHz (7,8 MHz) receiver bandwidth.

Network operators and broadcasters define a minimum Modulation Error Ratio (MER) performance limits for transmitters in a network. Typical MER values range from 30 dB to 36 dB dependent upon the modulation scheme and other network considerations such as low power secondary network transmitters (e.g. transposers). A reduction in MER increases the required C/N for a given modulation scheme, and consequently reduces the broadcast cell radius. This effect is commonly known as Equivalent Noise Degradation (END, dB), see ETSI TR 101 290 [i.1].

Reducing the ACLR of an adjacent DVB-T/T2 signal will further impact the MER of the victim service by the addition of out-of-band noise into the victim signal.

The tests described below were designed to investigate the impact for a range of ACLR levels on the MER of adjacent victim DVB-T services.

E.1   Equipment Configuration

Figure E.1 shows the test equipment setup used, this represents a co-sited transmitter system where all transmitters are connected into a single combiner and connected to a single antenna. The mean output power for each transmitter was equal and the modulation settings for both transmitters were configured to be the same in accordance to table 5.2.
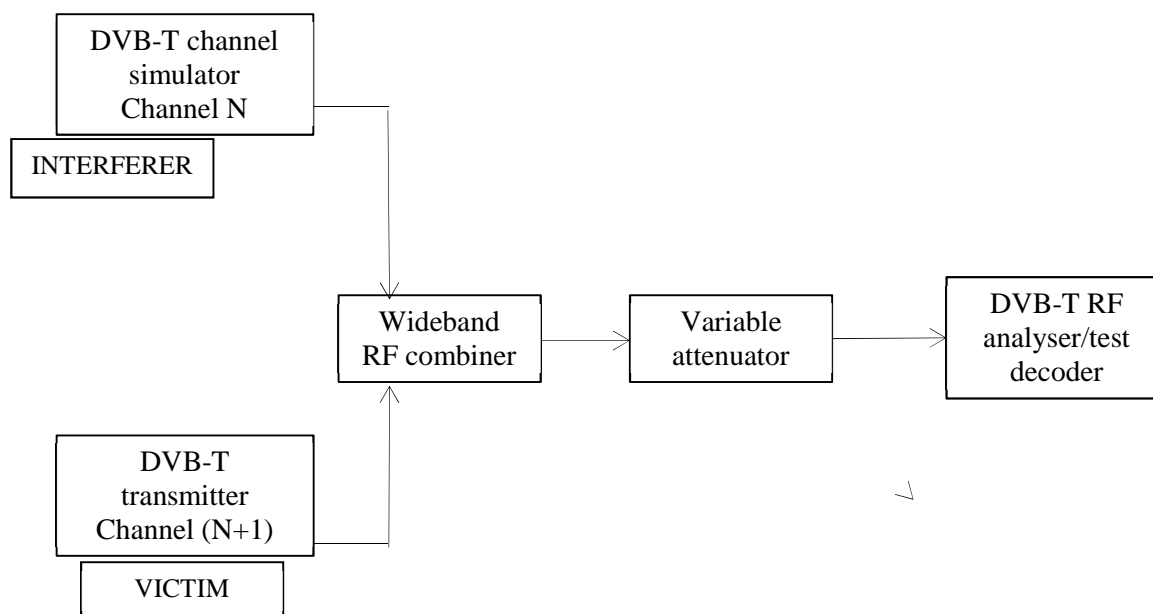

Figure E.1: Test Equipment Setup for ACLR Measurements

- Two tests were conducted representing two target MER values. The victim transmitter was configured to have an MER of 35,1 dB for test 1 and an MER of 35,9 dB for test 2.

- The interfering signal ACLR was varied in the range of between 32 dB to 57 dB.

- The MER of the victim signal was measured on the RF analyser as the ACLR of the interferer was varied.

The composite output of both the victim and interfering signals after the wide-band coupler can be seen in figure E.2.
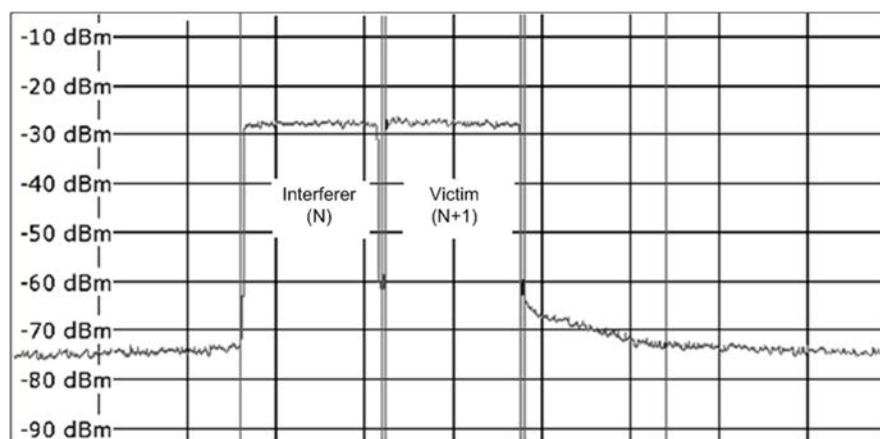

Figure E.2: Composite Output from the Wide-band Combiner

E.2 Results

The effective MER resulting from the increase of the ACLR from the adjacent signal into the victim signal can be seen in figure E.3.
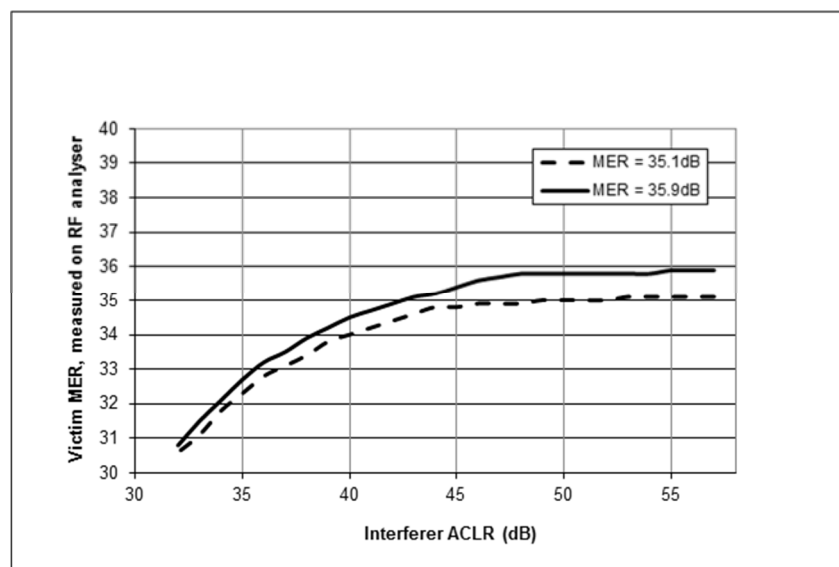

Figure E.3: Victim MER versus ACLR

E.3   Theoretical impact of MER on END

Figure E.4 shows the theoretical relationship between MER and END expressed in dB for the modulation schemes described in clause 5.3.2. END is a useful parameter which directly expresses the impact on the reduction of MER on the transmitted signal in terms of transmission loss (dB).
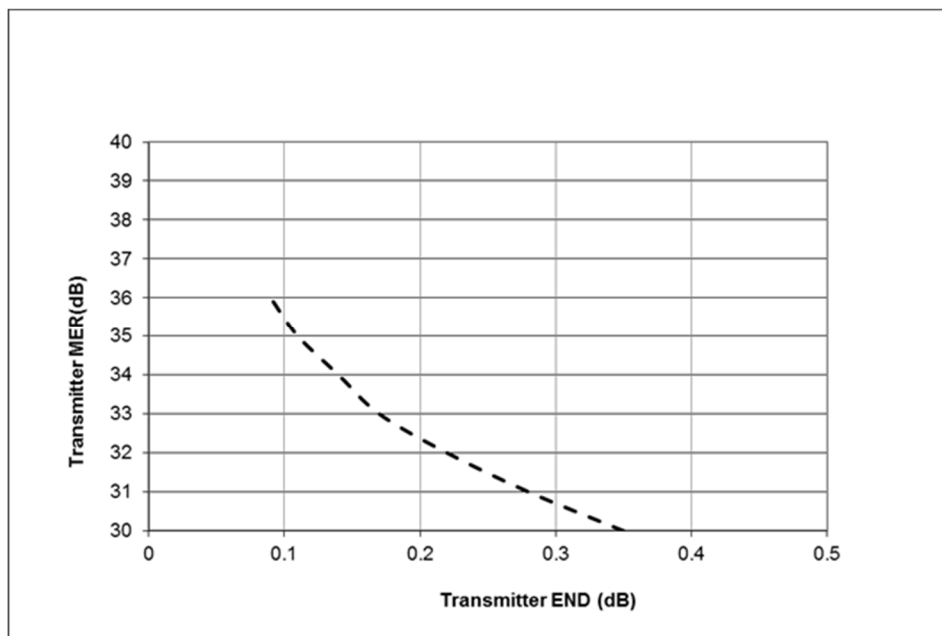

Figure E.4: MER versus. END

E.4   Conclusions

The above tests are for co-sited DVB-T/T2 networks and record the impact for a range of ACLR values from an adjacent DVB-T transmitter into a victim DVB-T service. The measured reduction in MER as a result in the change of the ACLR and the calculated END are also presented.

Figure E.3 shows that as the ACLR reduces there is a direct impact on the MER of the adjacent victim service. For both tests (MER configured to be at 35,1 dB and 35,9 dB), and with an adjacent ACLR of ≥ 42 dB, there is < 1 dB reduction in the received MER of the victim service.

Figure E.4 shows that within the selected operating victim receiver MER boundaries of this test (36 dB with no ACLR from the interferer to 31 dB MER with 33 dB ACLR from the interferer), the END for a 1 dB reduction in MER is increased by $< 0,06$ dB. This will have no impact on broadcast cell coverage.

Annex F (informative):
Maximum measurement uncertainty

The measurements described in the present document are based on the following assumptions:

- the measured value related to the corresponding limit is used to decide whether an equipment meets the requirements of the present document;

- the value of the measurement uncertainty for the measurement of each parameter is included in the test report.

Table F.1 shows the recommended values for the maximum measurement uncertainty figures.

Table F.1: Maximum uncertainty of the test system

Parameter	Condition	Uncertainty
Spurious emissions (Conducted emissions)	$f \leq 2,2$ GHz	2,5 dB
	2,2 GHz $< f \leq 3$ GHz	3,0 dB
Out-of-band emissions (Conducted emissions)		2,5 dB
NOTE: Please refer to EN 55016-4-2 [i.9], clause 4.1, table 1.		

Annex G (informative):
Bibliography

Recommendation ITU-R SM.328-10: "Spectra and bandwidth of emissions".

ETSI TR 101 190: "Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects".

ETSI TS 102 831: "Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2)".

CEPT/ERC/REC 74-01E: "Unwanted Emissions In The Spurious Domain", January 2011.

Recommendation ITU-R SM.1541-6 (08/2015): "Unwanted emissions in the out-of-band domain".

Recommendation ITU-R BT.1206-2 (06/2014): "Spectrum limit masks for digital terrestrial television broadcasting".

ECC Recommendation (02)05: "Unwanted Emissions", March 2012.

Annex H (informative):
Change history

Version	Information about changes
2.1.1	First published version covering Directive 2014/53/EU [i.2]. Major changes are: • The introduction of ACLR limits for the OOB domain for DVB-T/DVB-T2 transmitters.
2.2.0	Editorial changes to clause 5 which provide greater clarity regarding the measurement process.

History

Document history				
V1.1.1	January 2005	Publication		
V1.2.1	May 2011	Publication as ETSI EN 302 296-2		
V2.1.1	June 2017	Publication		
V2.2.0	January 2020	EN Approval Procedure	AP 20200408:	2020-01-09 to 2020-04-08
V2.2.1	March 2021	Vote	V 20210518:	2021-03-19 to 2021-05-18